Human Spaceflight Capabilities

Validation of On-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs, SDTO 17011 U/R (Braslet)

Completed Technology Project (2007 - 2010)

Project Introduction

Validation of On-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs (Braslet) is Station Development Test Objective (SDTO) 17011 sponsored by NASA and Russian Federal Space Agency (FSA). Braslet is testing the ability of ultrasound to detect cardiovascular changes in response to volume distribution changes that are induced by the Braslet occlusion cuffs. Understanding the effects of this countermeasure on cardiovascular function in a microgravity environment will be useful for both medical operations and future research.

See also

http://www.nasa.gov/mission_pages/station/research/experiments/356.html

Anticipated Benefits

Space Applications

This SDTO will provide refinements in remote guidance techniques which will allow detailed ultrasound exams to be performed in space with remote guidance by technicians and physicians on the ground. This will enhance the diagnostic and research capabilities of the International Space Station (ISS) ultrasound. Data will also be collected regarding the utility and potentially expanded uses of the Braslet-M device for both ISS and exploration class missions. A more detailed understanding of the cardiovascular response to microgravity-induced fluid shifts will also be gained from this work.

Earth Applications

Refinements in remote guidance techniques provided by Braslet will similarly allow detailed ultrasound exams to be performed in terrestrial locations remote from experienced ultrasound technicians and physicians. Examples include rural clinics, disaster areas, and military applications. Additionally, during this SDTO data will be collected regarding the physiological responses to altered circulatory volume distribution which may lend insight to the diagnosis and treatment of terrestrial conditions (such as cardiovascular disease) which result in altered fluid status.

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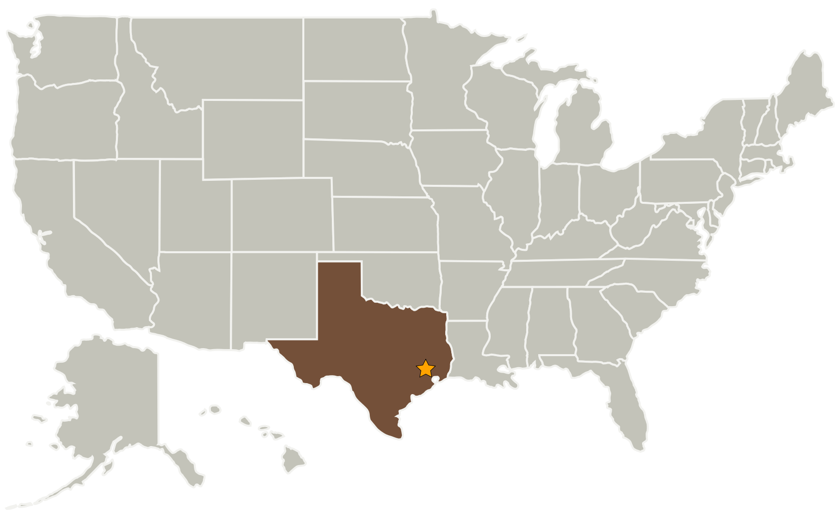
Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Project Manager:

Sharmila D Watkins

Principal Investigator:

James M Duncan

Co-Investigators:

V. Bogomolov
Douglas R Hamilton
Scott A Dulchavsky
Vladimir P Matveev
Ashot E Sargsyan
Douglas J Ebert

Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Gagarin Cosmonaut Training Center	Supporting Organization	International	Star City, Outside the United States, Russian Federation
Henry Ford Health System	Supporting Organization	Industry	Detroit, Michigan
Institute for Biomedical Problems, Moscow, Russia	Supporting Organization	Industry	
KBRwyle, Inc.	Supporting Organization	Industry	Houston, Texas
The University of Texas Medical Branch at Galveston(UTMD-Galv.)	Supporting Organization	Academia	Galveston, Texas

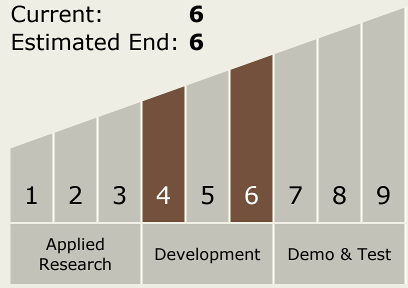
Primary U.S. Work Locations
Texas

Project Transitions

April 2007: Project Start

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  └ TX06.3 Human Health and Performance
    └ TX06.3.2 Prevention and Countermeasures

Target Destinations

The Moon, Mars

September 2010: Closed out

Closeout Summary: The Braslet SDTO was a limited in-flight investigation pursuing the development, testing, and validati on of novel non-invasive methodologies for cardiovascular system evaluation in conditions of space flight with an emphasis on using Braslet-M device for hemodynamic modification. The objectives of this study were fully met: • Non-invasive ultras ound measurement techniques for comprehensive cardiac and vascular evaluation were establish and validated • A method ology was developed and validated to assess the circulating volume changes and cardiac function in space flight conditions, through short-term hemodynamic modification using Braslet-M occlusion cuffs • The utility of Valsalva and Mueller respirato ry maneuvers as means of modifying preload and afterload was verified as a technique to obtain additional functional infor mation regarding the effect of Braslet and its clinical and scientific significance • The tissue Doppler capability of the Human Research Facility (HRF) Ultrasound was activated and tested The human body experiences significant volume shifts and red uction in venous reserve during extended exposure to microgravity. The cardiovascular system preserves effective circulati ng volume through standard homeostatic physiological response to reduced gravity. Therefore even though astronauts and cosmonauts are hypovolemic by terrestrial standards, they are euvolemic by space standards. This effect can be partially a nd acutely reverted towards terrestrial fluid distribution and overall hypovolemia through the use of Braslet. The Braslet-M device, when used per the current calibration and directions, consistently causes fluid sequestration in the vascular bed of t he lower extremities. This was demonstrated through the significant distention of venous reservoirs of lower extremities as detected by consistent increases in femoral vein cross-sectional area. This SDTO also demonstrated the effectiveness of the Braslet in temporarily reducing the effective circulating volume during space flight, as demonstrated by cardiac parameters which indicate a reduction in preload. Modified Valsalva and Mueller maneuvers resulted in measureable changes in hemody namic distribution. Although many of these changes did not reach statistical significance, the trends were clear. Since breat hing maneuvers were not tightly regulated or monitored, it is likely that the pressures created by these maneuvers varied fr om subject to subject, and even between individual data points within the same session. These variations in pressures may have resulted in a broader distribution of data points, precluding statistical conclusions in this relatively low n study. Howev er, due to clear trends and several significant indicators in the data, a healthy individual's volume status can be estimated b y observing specific effects of the Braslet-M device on the effective circulating volume when respiratory maneuvers are perf ormed. Initially the team expected the internal jugular vein (IJV) to be a simple and reliable indicator of fluid status. While t his is the case in most subjects, the variability in this data was large, perhaps due to the extreme compliance of this vessel. For example, simple actions such as speaking during scanning sessions resulted in large changes in the IJV area. The IJV is near maximal distention in chronic microgravity environments. The trends in the data indicate that Braslet relieved much of the excess cephalic fluid load and allowed a broader range of venous areas. While not achieving statistical significance, this is an excellent example of the synergy of fluid sequestration by Braslet superimposed with breathing maneuvers to broaden the range of sensitivity. This SDTO demonstrated that minimal crew training, combined with just-in-time on-orbit training a nd remote expert guidance, can be successfully used to complete complex medical diagnostic tasks such as advanced ultras ound examinations. Ultrasound was rapidly and accurately performed by all crewmember operators in a number of specific applications which have direct operational relevance to current and future missions and would provide direct, important me dical information to impact the diagnosis and treatment of in-flight medical conditions. The expanded ultrasound application s described and performed for this SDTO are also relevant to space medical and physiologic research. Minimal resources, tr aining, and crew time were required to complete these complex tasks; this should serve as a successful model for future sp ace flight operations and experiments. Elements of general telemedicine, training, and scanning techniques developed and r efined during this SDTO are already being incorporated into routine medical operations. Specific elements of vascular scanni ng and fluid shift alterations may be used in the near future to address pressing crew health questions related to intracrania l hypertension. The Braslet device has potential medical application due to its mechanism of action. Pulmonary edema seco ndary to left ventricular failure is caused by increased pulmonary venous pressure and ensuing interstitial edema. Nitroglyc erin acts through the release of nitrous oxide and its effect is modulated by vascular endothelial superoxide levels, to relax vascular smooth muscle. The principal benefit of these changes is to decrease systemic vascular resistance, increase venou s compliance, decrease pulmonary capillary wedge pressure and mean arterial pressure, which should relieve cardiac-induc ed pulmonary edema. Given the microgravity-induced cephalad fluid shifts and the changes in lower-extremity intravascula r volume, the use of common venodilators such as nitroglycerin may not be as efficacious in the immediate treatment of pul monary edema. It is known that rotating tourniquets or thigh cuffs induce lower extremity venous pooling and reduce the ci rculating blood volume, which reduces left ventricular end-diastolic pressure. This investigation showed that the Braslet thig h cuffs impede lower-extremity venous return but not arterial flow. A device like the Braslet can be used to treat congestive heart failure and orthopnea in many parts of the world as well as in reduced gravity environments. While Braslet imparts a

Stories

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/46590)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/46591)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/46592)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/46594)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/46593)

Articles in Other Journals or Periodicals
(https://techport.nasa.gov/file/46595)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/46596)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/46597)

Papers from Meeting Proceedings
(https://techport.nasa.gov/file/46598)

Project Website:

https://taskbook.nasaprs.com